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OBSERVATIONS ON TUNA-LIKE FISHES IN THE TROPICAL PACIFIC[1]

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In the years 1943 and 1944 the writer travelled extensively in the tropical Pacific setting up fisheries for the production of fresh food at advanced island bases. During the course of this work observations were made on tuna in places where American fishermen have seldom been and for that reason it has been felt that some value might be derived from setting them down. The following material is a brief resume of those observations.

Midway Island, September, 1943

No accurate record of the occurrence of tuna could be obtained from the personnel of the base, whose fishing efforts had been confined chiefly to the reef and lagoon. The commander of the naval base provided a motor whaleboat with a crew of two and permission to prospect outside the reef. During a three week period we fished extensively with trolling gear around the leeward half of the atoll to a distance of about seven miles offshore. The fish were never found over water shallow enough that the bottom colored the water, but they seemed to be in equal abundance in "blue" water, whether close in to the reef or as far out as we could venture. We had always to keep the island in sight, for various reasons, but there appeared to be fish in comparable quantity, as far as we could trace the activity of the sea birds, far on out to sea beyond the radius of our operations.

Four species of tuna-like fishes were present in abundance: the oceanic skipjack or aku (*Katsuwonus pelamis*), the black skipjack or kawakawa (*Euthynnus alletteratus*), the yellowfin tuna or ahi (*Neothunnus macropterus*), and the wahoo or ono-ono (*Acanthocybium solandri*). The oceanic skipjack appeared to be considerably more abundant than the black skipjack, but we could form no suitable estimate of the abundance of the latter two species, save that there were feeding schools of them in abundance, for the larger fish of both species destroyed too much of our gear.

Our vessel was 26 feet long, sharp sterned, and made six to seven knots. We could conveniently fish two troll lines from it on jerry-rigged oars for outriggers, and when fishing was particularly good we operated a third short line from the stern. Our line was tarred 96-thread hard laid cotton twine, which we found to be too light for the larger fish. Rubber stretchers in the line, made of inner tubes, permitted us to take fish up to about 60 pounds, with an occassional one up to 90 pounds, but large fish took our gear, and we lost most of them.

[1] Submitted for publication, March, 1946.

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We had ordinary tuna lures of two kinds, feather and bone. The feather lures appeared to be somewhat more attractive to the fish, but the fish bit the feathers off so that only two to six fish could be taken on a lure before replacing the feathers. There was a feeling, never adequately tested, that the fish showed a preference for lures with red feathers mixed in with the white ones over a lure of white feathers alone. Bone lures were definitely superior over feathers for skipjack even though the fish did not take them as well, because the bone made a convenient handle by which the fish could be shacked off the hook and, since speed in returning the lure to the water was essential when in a school, more fish were caught with them than with feather lures. For larger fish, however, they were not so good because the fish would straighten out the hook and escape, whereas the more flexibly attached hook on the feather lure seldom straightened out.

Fishing was done entirely, after some experience, by following the flocks of seabirds which were feeding on the same organisms as the fish. The birds were actively scouting for food all during the sunlit hours. They gathered over the spot where the fish would rise, some seconds or minutes before the fish came to the surface, in sufficient numbers that the flock could be seen for three or four miles, and they would follow a feeding school as long as it stayed at the surface. They furthermore seemed able to estimate where a school of fish would rise next with far better precision than we could, and when there were no fish in sight we formed the habit of idling the boat near a large flock of resting birds with the assurance that if they were not in the right place their scouts, which were always out, would lead them quickly to the right place before the fish rose to the surface. Fairy terns, because they were pure white and could be seen so far away, were particularly valuable in sighting distant schools as were the high flying frigate birds, but it was the mutton birds and boobies that formed the main mass of feeding birds.

From what examinations we made it was apparent that both birds and fish were feeding very largely, if not entirely, on small squid. Yellowfin tuna fed on these also and on flying fish. Wahoo seemed to never feed on the small bait and were normally not found where the birds were. Their presence, aside from their jumping (which was frequent), was indicated by flying fish, upon which they were feeding extensively. When a school of flying fish rose as a unit, in evident hysteria in short mass flights, we knew that there were either wahoo or yellowfin under them. The presence of flying fish was not related to the presence of skipjack.

Wahoo were feeding in schools, although we caught occassional isolated specimens. It was possible to tell school fish from isolated fish by the fact that school fish had their caudal fin badly abraded and we soon learned that when a fish had a bright shiny tail there was no profit in trolling longer in that spot, but if the tail was dull and worn at the tips we could often catch three or four more fish out of the school, which was seldom visible by surface signs, before the school sounded. We caught one wahoo of 90 pounds and several of more than 60 pounds, although the normal size was 15 to 20 pounds. This was undoubtedly due to the fact that large fish took our gear, for we often saw big wahoo tail dancing in the distance trying to shake out the hook from which trailed one of our broken lines. On one occassion we landed a wahoo which still had one of

our bone lures in its mouth from which trailed about 20 fathoms of our line.

Yellowfin were in abundance and were feeding both on squid and flying fish, usually the smaller specimens on the former. The fish we caught averaged between 25 and 35 pounds, although we caught them as small as eight or 10 pounds in weight. We never caught specimens weighing more than 60 or 70 pounds because their fierce strikes broke lines even worse than those of the wahoo. That larger fish were present was evident from the way we lost gear.

The oceanic skipjack ran from five to 20 pounds in weight, the black skipjack on the average ran a little smaller. These were the fish which we caught most abundantly. Whenever we trailed our lures across a feeding school of skipjack we could usually depend on getting a fish on every hook, and if the lines were cleared rapidly enough we could often get three or four fish out of the same school on the same hook before the school sounded. There was seldom a half hour during the day when schools of fish were not feeding in sight and, although the noise of our vessel drove the schools down soon after we approached, either it or another would appear again before long.

We were considerably handicapped by the slow speed of our vessel. The feeding schools of fish seemed to move along at from six to nine knots and, aside from the difficulty we had chasing them down, would sometimes just swim away from us on the surface. The one day that we borrowed the commodore's barge gave us the best fishing we had. A troller for that fishery should be able to cruise at nine knots and have as silent a motor and propeller as possible.

Even with the crude equipment that we had we finally came to the conclusion that two men in such a vessel with such gear could average four hundred pounds of tuna per day. This allowed for a trip in at noon to unload fish to the reefer box, which we had to do because we had no shelter from the sun for our fish. We estimated that if an ordinary small sampan, like those available in Honolulu, were obtained this average could be raised to 600 pounds per day.

If an efficient two man troller with refrigeration, good outriggers and gear, power gurdies, etc., such as are used in the albacore fishing off the State of Washington, were employed at Midway during the season that I was there surely the average daily catch would amount to somewhere between a thousand pounds and a ton per day, for I never saw albacore off the Washington coast in abundance which approached the daily condition at Midway. While we were fishing there there was no relation between the catch and the time of day. We were as apt to catch fish at noon as in the early morning or evening. No records had been kept of the fish catches before my visit and I know of none since.

Palmyra Island—Early October, 1943

At Midway we had fished the leeward side of the island through convenience; at Palmyra we were forced to the same practice through the incessant practice firing on the other side of the island so that we had no opportunity to explore the waters to windward.

The same species of fish were found. The black skipjack were rare; schooling wahoo and yellowfin abundant; and oceanic skipjack far more

abundant than at Midway. We were never able to get out in the early morning at sun-up, for various reasons, and the fishing was uniformly poor during the middle of the day, but after four in the afternoon the fishing was uniformly excellent, better than any tuna fishing that I encountered elsewhere in the Pacific.

It was customary to see skipjack off Palmyra in the late afternoon as far as the eye could see from a low vessel, the groups of small schools advancing in a crescent two or three hundred yards wide and stretching away in the distance either way. There was no necessity for starting a fishery there, men fishing with sport trolling gear were able to supply the fresh fish needs of the rather small garrison if boats were provided to get them out into blue water.

I have since talked with men back from a year and more at Palmyra and they reported that the fishing was excellent the year around whenever they could get out to sea.

Johnston Island—Mid-October, 1943

The experience at Johnston Island underlined a fact that was common to the service men at most Pacific island bases. No one knew there were tuna offshore because they never had a chance to get out in a boat to find out.

The commandant of the base was an enthusiastic fisherman, realized the need for fresh fish in the limited diet of the garrison, had organized a fishing detail of 14 men to provide the fish, and offered a monthly prize for the man bringing the largest fish. In spite of these efforts insufficient fish were being landed to fill requirements. The fishing was confined to the area adjacent to the reef; there is no lagoon proper there.

When I suggested, after arriving, that we try offshore fishing for tuna I was told that there were none in that vicinity. Having had so much luck to date in the lee of atolls we tried anyway, and soon located schools of wahoo, skipjack and yellowfin.

The reason why the schools had not been obvious at Johnston was that there were so few sea birds available that there was never a flock of them to point out the surfaced, feeding schools of fish, and this was a material inconvenience to the fishing. The only signs of surfaced fish were the splashings of the schools themselves or the leaping schools of flying fish. As a consequence it was necessary to spend considerable amounts of time trolling blindly.

It seemed apparent, however, that the fish were present in similar abundance as at Midway, a few hundred miles to the northwest.

Canton Island—Late October, 1943

There were no yellowfin or wahoo available. Pan-American personnel who had been on the island a year said that these species left the local waters in early September and did not become available again until late November. At other times of the year the fish were abundantly available to sport fishermen and that was a major source of relaxation to the air base personnel before the war. These statements were substantiated by independent conversation with Army personnel and Gilbert Island natives, the latter of whom were present on the island as a labor force.

Skipjack were available, and seemed to be moderately abundant but the schools were scattered and wild, and fishing was difficult with the type of vessel available.

The Gilbert Islanders caught skipjack in their native manner. They had built dugout canoes and trolled for skipjack in those vessels. When a school surfaced the crew would paddle like mad. The fisherman in the stern trolled a feather lure on a short line and splashed water on the lure with his other hand to confuse the fish into thinking it was a live bait. The method seemed incredibly crude but it was effective. The men said that in their home islands skipjack was their main meat food, and that they were abundantly available all around the islands.

New Caledonia—November, 1943—January to April, 1944

Our principal fishery was inside the great barrier reef, and the only-tuna-like fish we obtained was the Spanish mackerel (*Scomberomorus commersoni*) which is everywhere available, from New Caledonia up through the Solomons, in considerable quantities but hardly sufficient to base a major fishery upon. The fish we landed averaged about 12 pounds in round weight.

"Bluefin" tuna (presumably the Australian tuna) were said to be available outside the reef (which lies two to eight miles offshore), and were reportedly caught in considerable numbers further up the island, but we actually saw none of these fish.

New Hebrides and Solomons—December, 1943—April Through September (except August), 1944

Our fishery in these areas, only fleetingly in the New Hebrides, was for reef fishes which occurred in sufficient quantities for our purposes in these islands. Indeed a considerable local fishery for them could be established. Security regulations prevented us from trolling far from bases. We did, however, troll steadily from New Caledonia through the New Hebrides to Guadalcanal and thence to Munda. In the vicinity of the latter two bases we trolled extensively while running to and from our fishing grounds.

No yellowfin or wahoo were ever seen or taken. Both species of skipjack were abundant through the "Slot" from the southern Solomons to Munda. Schools of young skipjack, eight to ten inches long (the youngest seen by us in the Pacific), were seen and specimens taken between Guadalcanal and Florida Island. Rainbow runner (*Elagatis bipinnulatus*) and dolphin (*Coryphaena hippurus*) were taken. Marlin were seen but not taken. A tuna which resembled our bluefin, and was probably the dogtooth tuna (*Gymnosarda nuda*), was taken on three occasions near Gizo Island in the northern Solomons, the smallest specimen about seven pounds in weight, the largest about 35 pounds.

Schools of crevally (*Carangus sp.*) occur in New Caledonia, the New Hebrides, and the Solomons in large quantities. They drive food to the surface like skipjack, the sea birds work with them in a similar fashion, and it was not possible to tell the schools from skipjack at a distance. A strong difference between the two fish is that the crevally would not take a lure (nonschooling species which occur along the reef take a lure readily, if trolled slowly). These fish are the foundation of some, at least, of the statements that tuna would not strike a lure in the South Pacific.

Green Island—Nissan Group—August, 1944

In August we trolled up by Treasury Island and Bougainville to fish at Green Island. Here again we found tuna in closely adjacent offshore waters just as had been found in the Central Pacific. Wahoo were taken for the first time in our experiences below the Equator. Skipjack were abundant as were tuna, but the tuna was the dogtooth tuna and not the yellowfin. Again we lost gear to big fish and trolling, which had not been practical for us in the Solomons, became a productive means of fishing.

Bait Fish

Live bait, preferably of the herring tribe, is an essential of the tuna clipper type of tuna fishing, the type of fishery which is predominant in the Pacific.

In Hawaii the offshore fishery had been stopped at the outbreak of war. When I was there the Navy had begun to turn back vessels to the fishery but recovery was difficult because the fishermen could not take live bait in Pearl Harbor and could only get into Kaneohe Bay under strict regulations. No other location was known where favorable bait supplies could be obtained. The lack of live bait had been a restrictive factor on the growth of the tuna fishery in Honolulu before the war. There are not vast supplies of sardines, such as occur off Central America and Mexico, anywhere in the Hawaiian Islands.

Such small atolls as Midway, Johnson, Palmyra, Canton and Christmas islands have even smaller quantities of such fish and they are less easily obtained by reason of the omnipresent coral which makes seining futile. Except for small quantities, suitable only for auxiliary use of a small fishery, fish proper for a live bait tuna fishery are not available at such small islands and reefs.

In the Fijis the conditions are similar to those in Hawaii. There are considerable quantities of suitable fish and they could be netted, but the supply is apparently not adequate to a major fishery.

Sardine-like fish occur in considerable abundance in New Caledonia. The small species that we used seemed to be omnipresent in the shallow water along shore but was nearly always in rocky or coral areas where we could not seine. We were told by French fishermen that sardines schooled seasonally in vast numbers at the north end of New Caledonia and in the Loyalty Islands. These observations we had no opportunity to confirm personally. We had no bait seines or time for proper prospecting, but were left with the impression that substantial quantities of fish suitable for live bait would be found in the numerous large bays of New Caledonia if a proper investigation were made.

In the Solomon Islands we found sardine in considerable abundance at Gizo Island, in the harbor. It is probable that the same species would be found in the similar sandy bays of the Archipelago.

Our observations on bait fish were unsatisfactory but the essence of them is: (1) Suitable fish for this purpose will be at a premium everywhere in the area we covered, and will not be found in such abundance as they occur in southern California and Mexico anywhere in this area; (2) Around the atolls and smaller islets they will not be found in quantities of any consequence to a fishery; and (3) Around the larger land masses (Fijis, New Caledonia, New Hebrides, Solomons) proper prospecting as to seasonal schooling might reveal quantities of sardines useful, if not sufficient, for a major live bait fishery.

SOME EARLY SUMMER OBSERVATIONS ON MUSKRATS IN A NORTHEASTERN CALIFORNIA MARSH[1]

By ARTHUR L. HENSLEY *and* HOWARD TWINING

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Prior to the introduction of nonnative muskrats in California there were native species along the Colorado River and on the eastern border of the State in the Walker and Truckee River watersheds and in the tributaries of Honey Lake. (Twining and Hensley, 1943.)

One of the early nonnative muskrat introductions was the Mount Shasta Fur Farm established in 1930 four miles north of the town of McArthur on Mud Lake in northeastern California. Stock for this venture was reported obtained from the States of Ohio, Colorado, and North Dakota. The muskrats were first bred in pens and then later released into an area enclosed by a supposedly muskrat proof fence. However, between the years 1931 and 1933, numerous muskrats escaped from the enclosure and this brought about the invasion of the muskrats into heretofore uninhabited but suitable marshes in the Pit River watershed. (A review of other introductions of muskrats in the State of California appeared in a previous paper by the authors—Twining and Hensley, 1943).

Since this introduction into the Pit River, muskrats have become of ever increasing significance to the economy of this part of California. Trappers and small landowners on one hand find that muskrats furnish a welcome source of revenue in the winter months, while certain landowners on the other hand often are faced with a serious problem when muskrats cause damage by burrowing into irrigation structures such as canal banks and weirs.

The 193 licensed trappers who caught muskrats in the four northern counties of northeastern California in 1941 reported muskrats that season brought them a cash revenue of $67,247.11, a sum of quite considerable importance to this thinly populated part of the State. Since an additional number of muskrat trappers, mostly minors, did not report their catch, this total is a minimum and is considered only indicative of the potential value of the resource.

This is one of the many reasons why the California Division of Fish and Game under Federal Aid to Wildlife Project 5-R, A Survey of the Fur Resources of the State of California, felt that a part of the time allotted to the survey should be devoted to include a brief study of the life history of this animal.

[1] Submitted for publication, July, 1946. This study was part of Federal Aid in Wildlife Restoration Project California 5R, a survey of the fur resources of the State of California.

A typical muskrat swamp was selected and a study to determine the following factors undertaken:

a. Number of muskrat houses per given area and determination of the accuracy of this method as a census technique.
b. Numbers of muskrats in each house.
c. Numbers of nests in each house.
d. Numbers of young in each nest.
e. Time of breeding season.
f. Mating habits.
g. Predation on muskrats.

Gooch Swamp in the northwestern part of Lassen County near the town of Lookout was selected as the study area because of its favorable location, abundance of muskrat houses and easy accessibility to all parts of the marsh. The study was started on June 16, 1942 and continued to July 20, 1942.

This swamp is situated in the center of a 1,500-acre meadow and covers an area of approximately 365 to 400 acres, most of which consists of dense growths of tules and other aquatic plants. This is surrounded by open water the area of which varies according to season and availability. Water supply to the swamp is obtained mainly from two sources, from spring overflow of Egg Lake via Taylor Creek and from the Pit River. The Pit River supplies 14.66 second-feet of water as long as the river carries not less than 155 second-feet. During the period of this study (June and July) the flooded area varied from approximately 1,200 acres to about 650 acres. The water depth averaged about 12 inches in the adjacent flooded meadow and about 3 feet in parts of the swamp. The flooded area of the swamp later in the summer may fall to approximately 400 acres.

The meadow and shallow parts of the marsh are used for grazing purposes and in some years the northern part is cut for hay. In normal years the water is lowered in the swamp about the last of June shortly before haying harvest begins. During the period of this study there were 225 cattle, 38 sheep and 10 horses grazing on the southern half of the meadow.

In the season of 1940-41, November 16th to February 28th, the swamp was trapped by two trappers from Nubieber. Their reported catch was 408 muskrats of which they gave 108 to the property owner for trapping privileges and rental on a share cropping basis. This does not represent the entire catch from the swamp for there were other trappers working the swamp a few days at a time without the permission of the owner. Their catches in numbers are unknown.

In the season of 1941-42, the owner and an assistant trapped the swamp part time. They caught 430 muskrats for which they received an average price of $1.45 or a total of $623.50. Again there was some illegal trapping by other trappers.

Methods Employed in the Study

Muskrat Markings

The animals when caught were marked by toe clipping, tagging and banding for later identification. (For toe clipping see Fig. 41.)

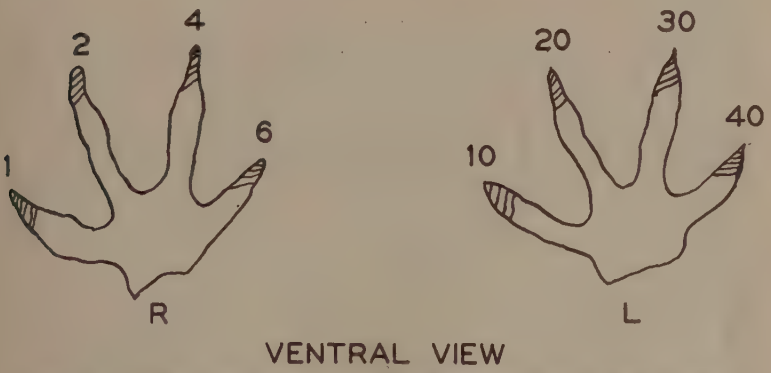

FIG. 41. Diagram of fore feet of muskrat illustrating the toe clipping formula. Animals were catalogued as 12, 32, etc.

The problem of catching muskrats uninjured for tagging and banding proved to be a complex one. Twenty-five rodent live traps were borrowed from the U. S. Fish and Wildlife Service but they were unsatisfactory. The trigger apparatus on the outside of the trap was easily fouled by the surrounding vegetation used in concealing the trap. The traps were constantly sprung by ducks, geese, rails, and other birds as well as by muskrats that were transporting new materials to the tops of the houses. Baits were found of no value in enticing muskrats into the traps. In 410 trap nights only eight muskrats were captured alive in the live traps. In several cases muskrats died in these traps during the night before they could be visited in the morning.

Victor Oneida No. 1 steel traps were tried and found to be even less satisfactory. As a rule the animal would either drown or "wring off" if left in the trap for more than one or two hours. In one instance 15 steel traps were set at one o'clock in the morning and revisited again at eight o'clock the same morning. During this time one muskrat had died in a trap and three others had succeeded in wringing out of the traps by twisting off their legs.

The tagging technique used is a modification of one developed in Iowa (Errington, 1937). Errington used aluminum bands which he passed through the loose skin of the back between the fore shoulders. He found that these often caused local infection of the injured tissue. In the present study a waterproof plastic button was threaded through the loose skin of the back with a flexible steel needle and secured with another button. The needle was bent in an arc so the buttons laid flat against the back. A total of 41 muskrats were thus tagged with buttons. No infections were

observed, but in the case of some young muskrats the parents apparently removed the tags.

A No. 7 bird band was used on adult muskrats. The band was placed around the base of the tail and closed firmly enough to be securely fastened without stopping circulation.

Muskrat Houses

In order to gather and list data the methods used were to cut a path through the tules from house to house and mark each house with a numbered card made fast in a slotted willow pole high enough to be seen above the tules while following the route of the path.

As each house was visited the house was opened for inspection by carefully prying off the top down to the interior of the nests in such a manner that it could be replaced with the least chance of injury to the house. In some instances this caused the animals to desert after the first inspection.

Results

Muskrat Markings

A total of 118 muskrats were captured and marked. Of these 110 were young, mostly captured by hand, and eight were live trapped adults. Forty-one of the young were tagged and toe-clipped and 69 were marked by toe-clipping only. The eight adults were marked with tags and with bands around the base of the tail.

Litters of young would usually disappear within a few days after their discovery; in no case were tagged or toe-clipped animals found in a different house from that in which they were originally captured.

Six of the marked muskrats were subsequently wounded; two were found in a fur house in Sacramento in a group of pelts from the Pit River area (they had scars on the back indicating that tags had been removed); and four were toe-clipped individuals that were seen in a trapper's catch from Gooch Swamp. No further data on the exact date or locality of recovery was available.

Muskrat Houses

As there are no precipitous banks on the swamp, the muskrats are forced to construct houses instead of excavating burrows in the banks. Structural materials are ordinarily piled from 24 to 30 inches above the water and the resulting heap usually measures three to five feet across the base. The basic substances used are tule stalks with tule roots and water-weed (*Elodea*) added for strength and sealing against the weather. These are also used as food.

During the full of the moon muskrats appeared to do much less work than at other periods, the feed beds took on a yellow unused and dry appearance. There was no new work on the houses and stool beds became dry with no fresh droppings showing.

Houses had from two to five entrances below water level, and exceptionally large houses had even more. Some entrances connected with a tunnel dug by the muskrats in the bottom of the marsh. These tunnels usually extended 10 to 12 feet out from the house and opened somewhere

in the floor of the marsh. When wading in the marsh the observers frequently caused these tunnels to cave in. Many houses had what we called "porch nests." These were found on the side of the house and were more or less open to the exterior. These spots were used only for loafing.

FIG. 42. Muskrat house on Gooch Swamp during summer.

Muskrats were observed several times sleeping on the "porch nests." When awakened by noise of approach, they would dive into the water and often would reenter the house through the tunnel in the swamp bottom.

Houses usually contain from one to four nests. The frequency distribution of numbers of nests found in 46 houses were as follows: 17 with one nest; 22 with two nests; 6 with three nests; and 1 with four nests. (Total of 83 nests in the 46 houses). In a few of the houses a nest was probably missed as it was necessary to use care not to break up the house too much in the search. The nests are lined with shavings peeled from the stems of bulrushes and with the leaves of dried sedges.

Muskrat houses were used as nesting sites by black terns, Forster terns, Canada geese and several species of ducks and other birds. By providing dry nesting sites well above water level, the houses make the marsh inhabitable for many of these birds. Bird nests built on muskrat houses are sometimes in danger of being buried by new material that muskrats add to the tops of their houses. Nine houses were found with one or more goose eggs buried within the lid of the house, indicating that the muskrats had covered the eggs while adding material to the house in the absence of the parent bird. Later investigations indicated this only occurs occasionally with late nesting birds or nests that have been deserted for unknown reasons.

FIG. 43. Adult muskrats on Gooch Swamp.

Mating

On June 19th a house was opened for inspection and an adult muskrat was seen to leave the nest which contained five young about eight days of age. The muskrat swam approximately 25 feet from the house and crawled upon a nearby feed bed that was occupied at the time by another muskrat which later proved to be a male. The two animals were then observed in the act of copulation four different times in about five minutes from the time the female appeared on the feeding bed. In two of the four cases in which the muskrats could be clearly seen the act lasted for about four seconds with short, spasmodic jerks on the part of the male after mounting the female.

Another litter was found at this house on July 16th. It was estimated to be two days old, making a period of 33 days between the estimated birth dates of these two litters. It is assumed that these two litters were produced by the same female as there were no indications of change of occupancy at this house during this period.

At another house a litter of three young estimated to be 12 days of age was found on June 18th. On July 10th another litter of seven young which were estimated to be two days old were found at this same house, making a period of 32 days between these two litters. Again it was assumed that these two litters were from the same female.

FIG. 44. One day old muskrats in nest at Gooch Swamp.

Care of Young

The mother muskrat gives her family good care by providing a comfortable and warm nest and spends a great portion of her time with the young until well after they are old enough to shift for themselves. While the eyes of the young are closed and they are quite helpless, the female has been observed to take as many as five youngsters at a time out of the nest and swim under water to a nearby feed bed with the young in tow attached to her teats. In one of these instances the female with young attached drew herself and family on to a feed platform within a few feet of the observers. She then busied herself with grooming and combing the heads and backs of the young with her front feet while they still clung to the teats. Ordinarily when the parent leaves a nest containing naked young, they are well covered with a layer of finely shredded, dry vegetation for warmth.

Occasionally when opening houses the mother muskrat was found lying on her side with the youngsters nursing. At one house the investigator was successful in catching the female by the tail and pulling her out through the opening made in the house roof. This female had five youngsters attached to the teats. The investigator endeavored to shake the young loose while holding the female by the tail but failed. After two or

three minutes of being held in this position, head down, and the youngsters still clinging tenaciously, she pulled the young loose one at a time and dropped them on the house top. She was then tagged and released but soon reappeared in a passageway of the house in search of the youngsters. As each young was marked by toe-clipping and tossed back to her, it was grasped by the skin of the back and shoved into the nest behind her. As soon as the last of the five young was received she immediately disappeared.

Growth of Young

The records obtained on muskrat growth were meager because of certain unforseen difficulties of procedure. In every case where newly born young were found in a house the litter disappeared within a few days. The toe-clipping and tagging experiments were in part designed to provide a check on these families but in no case were the young found located in

FIG. 45. Six day old muskrats at Gooch Swamp.

another house. Often the mother and the young muskrats would succeed in leaving the nest while the house was being opened by the observer. In several cases the youngsters eyes would show a slight opening at 10 days.

On June 23d, two newly born young were found in a house. They measured 4 inches in total length. Six days later eight were found in the same house. Three of these measured 6 inches and five measured 5½ inches. The eyes were not yet open. The following day this house was empty. While later inspections showed it was not desertion, this family was not again observed.

Senses

In many instances the investigators were impressed by the wide differences in sensitiveness of individual animals to their approach. It was assumed that the animals seen by the observers were those that had particularly dull senses or else were ones that were especially bold. While watching muskrats that were feeding, resting, or sleeping, several times the observers noticed that the animals were not obviously disturbed by

normal conversation. On two or three such occasions when the investigators would imitate the screech of a red-tailed hawk, the animal under observation would dive into the water instantly. Noise of approach would cause muskrats to pause in their feeding and become alert for seconds at a time before resuming their feeding or in some cases disappearing from sight. At times they would raise their heads and wriggle their noses as though trying to identify a foreign scent. Swimming muskrats would sometimes pass within a few yards of an observer although any movement or sound, ever so slight, on the part of the observer would cause them to submerge immediately.

Deaths

Only four dead muskrats were found: one, a small young in the nest; another, a halfgrown muskrat near an occupied house; a third, a youngster that had been toe-clipped; still another, an adult found in deep water. Causes of these deaths were undetermined. In practically all cases the young had numerous ectoparasites (chiefly mites) distributed over the body.

Muskrat Enemies

The mammals and hawks seen in the vicinity of the swamp that might be considered as predators of muskrats were:

Mink	Duck hawk
Coyote	Marsh hawk
Horned owl	Cooper hawk
Barn owl	Sharp-shinned hawk
Red-tailed hawk	

Three muskrat houses were found being used by mink. One of the houses was occupied by a female mink and her two young. The young were caught and marked with water proof plastic tags between the shoulders. The house was deserted after the tagging. At the time of tagging remains of the following species were found on top of the house: three coots, one Canada goose gosling, three eared grebes, and one black tern.

Evidence of mink preying on muskrat litters was observed by one of the investigators while traversing the north end of the swamp on the daily inspection trip. A pronounced mink odor was detected coming downwind from an unexplored portion of the swamp. Following this lead through the dense tules for a distance of approximately 50 feet, a muskrat house came into view. It was obvious that a violent commotion was in progress inside, for the entire roof was shaking. Loud squeals and sharp growls could be heard. The observer approached quickly to within 10 feet of the house when all activity within seemed to cease. One animal was noticed to leave, swimming just under water, leaving a wake and numerous bubbles. It quickly disappeared in the thick tules.

When the house was opened, a baby muskrat estimated to be about six days of age was found freshly killed by bites and lacerations. It had been bitten through the skull and throat and through the back and stomach. The right rear leg was pulled off and missing. The animal was still warm. A powerful odor of mink issued from the house when the top was lifted. The nest had been torn up but it was still warm, indicating

that it had been recently occupied by a family of young. The house had every appearance of being normal and the absence of bird carcasses, as found on the other three houses occupied by mink, further supported this opinion.

These observations suggest that a mink entered the muskrat house to prey on the young and was caught in the act by the parent muskrat. The fight that followed was broken up as the investigator approached.

Coyote tracks were observed in and around parts of the swamp and, on at least one occasion, a muskrat house which had been broken into, was surrounded by tracks in such manner that it seemed likely a coyote was the marauder.

Hawks were seldom seen but when they did appear flocks of yellow head blackbirds, black terns, and Forster terns rose to meet them and harrassed them so vigorously that they hurriedly left the vicinity of the swamp. Therefore, the actual status of the hawk as a predator was not fully determined.

Discussion

It is estimated that 85 per cent of the muskrat houses on the area studied were found in this survey. These were within an area of approximately 350 acres of the swamp. Sixty houses were kept under close observation. Thirty-five of these were occupied by one or more muskrat litters, 40 litters in all, containing 187 young. The size of the litters ranged from two to eight, the average being 4.67. Whenever possible the litters were counted several times to increase the probability that all young in each litter were included. Litters of all ages were counted; no account was made of young that may have died before counting was done. Three different houses contained two litters of different ages at the same time. Two additional houses contained first and second litters during the period of study.

The fate of these litters still remains unknown. Promises that were made by the owner of the swamp to keep a complete record of all animals caught carrying tags or toe clips during the coming fur season were not fulfilled. The owner trapped only one week of the season with a few traps set and took a number of pelts; in one batch of 25 muskrats examined by us four were toe-clipped. The owner suddenly disposed of the property and moved elsewhere. The new owner leased the trapping rights on the swamp to a commercial fur trapper who made no effort to cooperate.

One of the investigators found two muskrat skins from the area in a local fur dealer's establishment in Sacramento, California, showing scars where the tags had been removed but was unsuccessful in ascertaining where they were captured or by whom.

Banding and tagging of muskrats unless diligently followed up by well trained investigators is of no value, since commercial trappers are prone to withhold information concerning their catch of marked animals.

During the study it was apparent that a census method could be developed and applied on certain swamps where there are no precipitous banks for muskrats to burrow into, by a complete count of muskrat houses. Such a method would help land owners or trappers interested in managing a muskrat crop for commercial trapping, either by themselves or on a share-cropping basis.

Summary

Gooch Swamp is situated in the center of a 1,500-acre meadow and covers a water area of approximately 365 to 400 acres, most of which consists of dense growths of tules and other aquatic plants.

Live trapping with live traps constructed with outside trigger mechanism was found ineffective. Steel traps proved unsatisfactory for capturing muskrats alive and uninjured. A total of 118 muskrats were marked, of which 110 were young captured by hand.

Muskrat houses had from two to five entrances under water and exceptionally large houses had even more. Houses usually contained from one to four nests. Forty-six houses had a total of at least 83 nests. More contained two nests than any other number. Muskrat houses were used by waterfowl and shore birds as nesting sites. In some instances these nests were buried by new materials added to the tops of the houses.

In two instances two different litters, presumably from the same parent females, were found with 32 and 33 days between births.

The muskrat mother is a devoted parent and takes good care of her young. She moves the young about in their early life by attaching them to her teats.

Mink were found occupying muskrat houses as well as preying on the young.

It was estimated that 85 per cent of the muskrat houses on the swamp were located during the study. Sixty houses were kept under close observation; 35 of these were occupied by 40 muskrat litters containing 187 young, or an average litter of 4.67.

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THE FOOT WORM PARASITE OF DEER[1]

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The foot worm of deer is a round worm parasite, *Onchocerca cervipedis* Wehr and Dikmans 1935, of the family Filariidae, which occurs in subcutaneous tissue, primarily in the deer of western North America. De Nio and West (1942) published a paper which might infer that this parasite is chiefly confined to a more or less limited range in western Montana with sporadic occurrence elsewhere. Published reports plus data which have been obtained by the authors and others indicate a much wider geographical distribution.

History

A filariid worm, *Onchocerca flexuosa* (Wedl), first described in 1856, frequently has been reported from deer in Europe. As early as 1893 Dr. A. Hassall identified what he considered to be this species of worm from a deer in Washington, D. C. (Dikmans, 1933). Dikmans (op. cit.) also reported *O. flexuosa* from subcutaneous tissues of an antelope (*Antilocapra americana*) from Salmon River, Idaho and from a subcutaneous abscess of a deer from Boulder, Colorado.

Rush (1935) reported two cases of infected feet of deer (apparently both white-tailed deer, *Odocoileus virginianus*) in western Montana. Rush stated that the worms were identified as *Onchocerca flexuosa* by the Zoological Division of the United States Bureau of Animal Industry.

On the basis of further study of specimens from the same area in Montana (possibly the original material submitted by Rush) plus specimens from Gambier Island, Howe Sound, British Columbia, Wehr and Dikmans (1935) established the name *Onchocerca cervipedis* for these worms and it is probable that the parasites reported earlier as *O. flexuosa* from North American deer may also belong to this species. Rush reported the worms from all four feet although Wehr and Dikmans, in giving the location in the host, leave the impression that the worms were known only from the hindquarters. Wehr and Dikmans list as hosts both the white-tailed deer (*O. virginianus*) and black-tailed deer (*O. columbianus*) and "probably" *O. hemionus.**

Annereaux (1941) reported the first published record of foot worm in deer from California. The worms were observed in a section of skin removed from the region of the hock joint of a mule deer which was killed in September, 1940, near Truckee, Nevada County.

[1] Submitted for publication, August, 1946. Much of the material for this study was made available through the cooperation of Federal Aid in Wildlife Restoration Project California 15R, a study of the influence of seasonal and other factors on the food value of the meat of game animals. The authors are indebted particularly to Carl Tegen of the Bureau of Game Conservation, and to various wardens and other personnel of the California Division of Fish and Game and to hunters and food locker personnel who aided in the collection of material.

* Recent classification (Cowan, 1936) revises *O. columbianus* to *O. hemionus columbianus* (Columbian black-tailed deer) and *O. hemionus* to *O. h. hemionus* (Rocky Mountain mule deer).

De Nio and West (1941), continuing the investigations begun by Rush in the Northern Rocky Mountain Region (Region 6) of the United States Forest Service, reported foot worms from a number of deer and one elk in Idaho, Wyoming and Montana (mostly from western Montana). Both white-tailed and mule deer were involved. In one area in Montana 70 per cent of 61 deer were infected. The worms occurred mainly in the feet but in one animal were collected overlying the shoulder blade and, in another, high up in the hind leg near the rump. Their data was apparently based mainly on a questionnaire to the game wardens, hunters, and others, and not from actual collections of the worms. In this original presentation De Nio and West referred to the parasites as *Onchocerca flexuosa* but in their later work (1942), which is primarily a reworking of the same data, they classified the worms as *O. cervipedis*.

Herman (1945) reported these worms as occurring in several areas in California. In a brief preliminary report of the data presented in this paper, the authors (1945) reported the examination of the feet of a number of deer from California and in three areas from which a large series was examined found an incidence of from 49 to 81 per cent.

Cowan (1946) reported 35 per cent of 40 deer (*O. h. columbianus*) examined from southwestern British Columbia infected with *O. cervipedis*.

Methods

Most of our study was based upon actual examination of deer feet in the laboratory. The specimens were obtained from two chief sources, material collected by field personnel of the California Division of Fish and Game and feet from animals shot by hunters. In the former case the material was submitted fresh (this includes all specimens from Marin County), or preserved in 5-10 per cent formaldehyde (feet from Santa Barbara, Ventura and Yolo Counties). The specimens from hunters were obtained through the cooperation of game wardens and food locker plants or by actual collection in the field by the senior author. All these feet were preserved by refrigeration. Usually the feet were severed at the hock joint and only the distal portion submitted for examination, although in many cases hide from above this area was included. In several cases an opportunity was afforded to examine the entire carcass of an animal and in many cases entire fresh hides were examined in the field.

In the laboratory an average of 15 minutes was spent in the examination of each foot. All worms or portions thereof were collected and preserved in 70 per cent isopropyl alcohol with the exception of a few in tissues preserved for sectioning. They were individually examined with the aid of a compound microscope to determine sex. Total counts of the number of worms present were based on the number of head or tail ends of worms, whichever was the greater.

Results

Incidence and Geographical Distribution

Our first contact with this parasite was a specimen of a dissected hock joint from a deer sent to our laboratory in October, 1942, by the late Dr. W. J. Lempke, a veterinarian in Arcata, California. We were unable to obtain information on the original source of this material. It contained 73 worms, the heaviest infection we have observed.

Since this first evidence of these worms came to our attention we have examined one or more feet from over 344 deer and 52 prong-horned antelope (*Antilocapra americana*), all from California. The total represents the examination of 1276 deer and 200 antelope feet. Examination of the deer yielded parasites from 480 feet, representing 193 infected deer. All the antelope were negative for this worm.

Deer specimens were obtained from 16 counties and infection was found in all but three. From three of the areas (Santa Barbara-Ventura Counties, Marin County and Yolo County) the feet were obtained during special studies on deer by field personnel of the California Division of Fish and Game and exact locality is known. Most of the other specimens were taken by hunters during the legal hunting season, and in most of these only a county designation of source was obtained. With a few exceptions all deer examined were mature males.

Table 1 presents the findings in deer feet examined by counties in California. The material from Marin County was obtained throughout the year, five animals per month, from February, 1944, through March, 1945. The specimens from Santa Barbara-Ventura Counties were obtained approximately at the boundary of these two counties, from February, 1944, through February, 1945. These animals were collected as part of a study on the influence of seasonal and other factors on the food value of venison. The specimens from Yolo County were all obtained from the Capay Valley during May, June, July and September, 1945; the material collected in September included feet from several fawns, all of which were negative. Tables 2, 3, and 4 show the monthly variation in incidence of infection in these three areas. These data seem to indicate a possible higher incidence of the worms during the winter months. However, since nothing is known of the life cycle of these parasites, there seems to be no justification in assuming that deer become infected at any particular season of the year.

The animals examined from Yolo County included 37 does, of which 22, or 86 per cent, were infected; 18 bucks, of which three, or 17 per cent, were infected; and six fawns, none of which was infected. Infection was found in yearling as well as adult animals.

Of the material from other counties, in most cases we can not be definitely certain of the source. Most of this material was obtained during the legal hunting season in 1945: deer from Monterey County August 1st through September 15th; Mendocino County August 15th through October 1st; all other counties from September 16th through October 15th.

Feet from 10 deer were obtained from Modoc County during the legal hunting season in 1945. Of 24 feet from these animals, one worm was found in one foot. During January, February and March, 1946, 14 deer were obtained from Modoc County. Two of these were mature bucks, the others were mature does. One of the males and 11 of the females were infected.

Infected deer included Columbian black-tailed deer, Rocky Mountain mule deer and California mule deer (*O. h. californicus*).

Number of Worms in Infected Deer

The greatest number of worms in a single foot was 73 from a specimen of unknown source. In the rest of the infected deer, infection ran from one worm to as many as 35 per infected foot. All four feet of this animal were infected and 74 worms were collected. Most infected feet

yielded only a few worms. In one deer examined in Montana, Rush (1935) stated that each foot yielded 20 to 30 worms. In two infected deer from British Columbia, Cowan (1946) estimated in excess of 200 worms present in each animal.

Size of Worms

The chief characters which set this parasite apart from *O. flexuosa* are primarily in the males of the worms. Various measurements presented by Wehr and Dikmans might perhaps be considered based on insufficient material and the location in the host is undoubtedly an inadequate criterion due to the limited data available to them at the time they prepared their manuscript. Sandground (1938), on the basis of certain anatomical features, questions the validity of the diagnosis given to *O. cervipedis*. No attempt is made in the present paper to substantiate the validity of the classification of these worms, but since our specimens agree in most respects with the description presented by Wehr and Dikmans, our specimens are reported as *Onchocerca cervipedis*. Further study is necessary to evaluate the questions raised by Sandground.

In an examination of 452 entire females, length varied from 85 to 225 mm. The average length of these worms was 151.6 mm. Of 23 entire male worms, length varied from 30 to 55 mm. The average length of males was 43.8 mm. Wehr and Dikmans (1935) give the length of the females 180 to 200 mm.; length of males, 55 to 60 mm. Annereaux (1941) stated the females to be 140 to 220 mm.; males, 40 mm. Cowan (1946) reported the worms from deer in British Columbia were often 8 inches (202 mm.) or more in length.

Sex Ratios

Of 1559 worms, determined by the number of heads or tails, whichever was the greater, 1533 were females and 26 were males, or a sex ratio of 1.7 :100. The authors feel that, even though the females are larger and more readily located than the males, no parasites were missed. In many cases fragments as small as 5 mm. were collected. It is possible that in such cases head or tail ends may have passed uncollected, but probably not in sufficient numbers to change this ratio materially. In many other round worm infections the females greatly outnumber the male parasites. There was no correlation between the total number of females present in a single foot and the possibility of overlooking a male worm and, in fact, in at least one case a single worm found in a foot proved to be a male. From a number of feet numerous gravid female worms were collected without observing a male. It seems logical to conclude that male worms were present in these infected deer above the hock joint or in some area of the animal's body not submitted for examination.

Location of Worms in the Host

In Table 1 is tabulated the percentage of total infection in fore and hind feet, and examination of these data demonstrates that there is about an equal change of the worms occurring in either of the two extremities.

Seven deer carcasses were examined in their entirety in the laboratory. Careful search was made particularly of the neck and back regions, bearing in mind the location in the host of other worms of the genus *Onchocerca*. No worms were found except a few in the feet of one of these animals. Further study of heavily infected deer is needed to clarify the

extent of distribution of these worms in the body of the host. All 14 deer examined from Modoc County were superficially examined in all parts of the body and five of the infected deer were carefully examined in the region of the mouth, head, neck and back as well as the more proximal portions of the extremities but worms were found only in the feet, with the greatest numbers about the region of the hock joint.

Over 70 fresh deer hides were examined in the field by the senior author and a number of hides from the animals collected at both the Santa Barbara-Ventura and Marin areas were examined by field personnel. A number of these deer were found, subsequently, to be infected in the feet, but no worms were found on the inner side of the hides.

De Nio and West (1941, 1942) reported worms only from the feet except in one animal in which worms were also observed located in the connective tissue overlying the shoulder blade. Cowan (1946) reported two cases in which he found worms in the intermuscular and subcutaneous tissue of the legs, sides, and even on the back, though progressively less abundant on the regions further removed from the lower legs.

The worms occurred most frequently, in our study, more or less loosely coiled on the under surface of the skin, the greatest numbers lodging in the skin over the hock joint. In some cases such loosely coiled worms were found in the muscle tissue and joint. On occasion the worms were tightly coiled into a small ball and sometimes such cyst-like formations were calcified At present miscroscopic studies of the material have not been completed.

Pathology and Pathogenicity

Rush (1935) reported evidence of pain in infected deer, loss of digits, swelling and ulceration as caused by infection with this parasite. Open lesions were at the site of encysted worms, which Rush concluded were responsible for foot sores. Some open lesions attained a size of about one inch in length. De Nio and West (1942) reiterated the findings of Rush and although they state that no animals were found whose death could be attributed directly to the parasite, loss of hoofs and dewclaws, or even soreness due to this disease, undoubtedly affect the animals' mobility. Cowan (1946) found no deleterious effects upon the host chargeable to the presence of foot worms, not even local inflammation in the region surrounding the parasites. It was because of the harmful effects of these worms, such as reported by De Nio and West, that the present survey was undertaken. If heavier infections are discovered in deer in some area of California, it plausibly might be expected that such infected animals would be slowed up in their activities making them easier prey to predators and hunters.

In all the infected feet we examined we found only three animals with lesions which might be due to the worms. In three animals we found small sores, about 2 to 5 mm. in diameter, upon the surface of the skin. In all cases these small lesions were attributed to the worms, and in one case a gravid female was found protruding through the lesion. This finding may be an indication of the type of life cycle of the parasite, nothing of which is known. No microfilariae were observed in blood smears from any of the animals. Several attempts were made to find microfilariae in fluid or scrappings of the skin in an effort to discover a technique for diagnosing infection in living animals but the only case where microfilariae were observed was when an adult female worm was ruptured.

In no instance, in the feet that we examined in this study, did we find any visible evidence of harmful effect of any kind as a result of these worms. However, further work with deer from other areas might reveal heavier infections or actual cause of disease in deer.

Summary

Onchocerca cervipedis is a round worm parasite which occurs particularly in the lower extremities of deer, possibly also in elk and pronghorn antelope, in western North America. It is reported from deer from a number of areas in California and in three areas where larger numbers of deer were examined, incidence varied from 42 to 80 per cent. Infection seemed to be higher during the winter months. No foot worms were found in the 52 antelope examined.

The greatest number of worms collected from a single foot was 73, although most infected feet yielded only a few worms. Female worms varied from 85 to 225 mm. with an average length of 151.6 mm.; males varied from 30 to 55 mm. with an average length of 43.8 mm. Only 1.7 males was collected to each 100 females. Worms were found only in the feet, particularly concentrated in the region of the hock joint. They were about equally distributed in fore and hind extremities.

Lesions were found in three feet, varying from 2 to 5 mm. in diameter and opening on the surface of the skin. In all cases these lesions were attributed to the worms and in one case a gravid female was found protruding through the opening. No visible evidence of harmful effect to the deer was observed.

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TABLE 1

Incidence of Foot Worms in Deer in California

County	Deer examined	Deer infected	Per cent deer infected	Number feet examined	Number feet infected	Per cent feet infected	Number fore feet examined	Number fore feet infected	Per cent fore feet infected	Per cent total infection in fore feet	Number hind feet examined	Number hind feet infected	Per cent hind feet infected	Per cent total infection in hind feet
Marin	71	35	49.2	272	67	24.6	130	30	23.0	44.6	142	37	26.0	55.2
Yolo	64	27	42.1	256	76	29.5	128	34	26.5	44.0	128	42	32.8	55.0
Ventura-Santa Barbara	65	52	80.0	250	147	58.0	120	70	58.3	47.6	130	77	59.2	52.3
Lassen	39	20	51.2	137	44	32.1	68	23	33.8	52.2	69	21	30.4	47.7
Monterey	19?	11?	57.8?	58	24	41.3	30	11	36.6	45.8	28	13	46.4	54.1
Humboldt	14?	11?	78.5?	43	18	41.8	22	9	40.9	50.0	21	9	42.8	50.0
Tehama	14	11	78.5	45	28	62.2	22	13	59.0	46.4	23	15	65.2	53.5
Mendocino	12	9	75.0	45	15	33.3	22	8	36.3	53.3	23	7	30.4	46.6
Modoc	24	13	54.1	80	41	51.2	38	21	55.2	51.2	42	20	47.6	48.8
Plumas	6	4	66.6	24	14	58.3	12	8	66.6	57.1	12	6	50.0	42.8
Mariposa	---?	---?	---?	11	6	54.5	5	3	60.0	50.0	6	3	50.0	50.0

TABLE 2

Incidence of Foot Worms in Deer from Santa Barbara and Ventura Counties

Month	Number deer examined	Number deer infected	Per cent deer infected	Number of worms	Average number worms per deer
February	5	3	60	--	--
March	5	2	40	10	2.
April	5	3	60	5	1.
May	5	4	80	60	12.
June	5	4	80	17	3.4
July	5	4	80	28	5.6
August	5	5	100	22	4.4
September	2	3	60	12	2.4
October	5	5	100	17	3.4
November	5	5	100	162	32.4
December	5	4	80	30	6.
January	5	5	100	113	22.6
February	5	5	100	75	15.

TABLE 3

Incidence of Foot Worms in Deer from Marin County

Month	Number deer examined	Number deer infected	Per cent deer infected	Number of worms	Average number worms per deer
February	5	3	60	--	--
March	5	1	20	1	.2
April	5	1	20	1	.2
May	5	1	20	2	.4
June	5	3	60	5	1.
July	5	3	60	4	.8
August	5	4	80	9	1.8
September	5	3	60	16	3.2
October	5	4	80	7	1.4
November	5	2	40	8	1.6
December	5	5	100	23	4.8
January	6	2	33	3	.5
February	5	2	40	6	1.2
March	5	3	60	20	4.

TABLE 4

Incidence of Foot Worms in Deer from Yolo County

Month	Number deer examined	Number deer infected	Per cent deer infected	Number of worms	Average number worms per deer
May	4	2	50	22	5.5
June	20	7	35	89	4.45
July	24	15	62.5	116	4.8
September	10*	3	30	8	.8

* Six fawns (all negative) also examined in September.

EDITORIALS AND NOTES

RETIREMENT OF GORDON H. TRUE, JR.

On account of ill health, Gordon H. True, Jr., Assistant Chief of the Bureau of Game Conservation, Division of Fish and Game, gave up his work with the Division on August 1, 1946.

Mr. True had been in the service of the State since his appointment to the field force in 1930. By inheritance and education he was well qualified for his appointment. His father, Professor G. H. True, was one of the foremost men in his work of animal husbandry in the world and was head of that department in the University of California.

Mr. True's training at Berkeley and Davis was directly along the lines necessary in the work of the division. For the first few years Gordon worked in various parts of the State and in 1935 was called from Southern California to the head office in San Francisco with the real work of Assistant Chief of the Bureau of Game Conservation although that position was not actually set up until months later. Mr. True proved his ability and from time to time was given more responsibility.

With the setting up of the Federal Aid to Wildlife Restoration Projects (Pittman-Robertson) in the State, he has been directly responsible for the building up of the staff and for the work that has been accomplished, work that by those who know is regarded as outstanding.

During the past nine years he has been active in the work of the Western Association of State Game and Fish Commissioners and as Secretary-Treasurer of that organization has taken a leading part in conservation matters in all of the western States.

To him in his new home in Nevada County go the best wishes of the entire division for the restoration of his health and for greater financial prosperity.—*J. S. Hunter, Chief, Bureau of Game Conservation, California Division of Fish and Game, August, 1946.*

NOTICE OF COMMISSION MEETINGS TO ESTABLISH SEASON AND BAG LIMITS ON SPORTS FISHES

The Fish and Game Commission will meet in Los Angeles on January 3 and 4, 1947, to hear recommendations for the coming fishing season as they pertain to seasonal bag limits. The Commission will consider these recommendations under the Regulatory Powers section of the Fish and Game Code, which says that the Commission ". . . shall receive recommendations from its officers and employees, from public agencies, from organizations or private citizens, and from any interested party."

The second meeting will be held in San Francisco on January 24 and 25, 1947, and at or prior to this second meeting the Commission will publicly announce its determinations and the orders it intends to make. The Commission will hear and consider any objections to its determinations and proposed orders, as well as any further discussions on the recommendations as submitted at the earlier meeting.

The Commission, according to the code, may:

(a) Establish, extend, shorten, or abolish open seasons and closed seasons.
(b) Establish, change, or abolish bag limits and possession limits.
(c) Establish and change territorial limits for the taking of any or all species or varieties.
(d) Prescribe the manner and the means of taking any species or variety.
(e) Establish, change, or abolish restrictions based upon sex, maturity, or other physical distinctions.

—Emil J. N. Ott Jr., Executive Secretary, California Fish and Game Commission, October, 1946

NOTICE TO DUCK HUNTERS

The United States Fish and Wildlife Service is asking the duck hunters to cooperate during the present hunting season in securing data which will be of help in working out fair regulations. The hunter is requested to keep a tally of the birds he bags, cripples or observes this fall and, at the end of the season, send a complete score card to the United States Fish and Wildlife Service, Chicago 54, Ill. Readers of *California Fish and Game* are urged to cooperate in this program. Below is an example of the type of information desired.

Scorecard

How many, what kinds of ducks, geese bagged	How many cripples lost	Compared with last year waterfowl numbers were		
		More	Less	Same

Shooting Grounds (Check One)

Public ☐ Commercial ☐ Private ☐

Where you hunted_____ How many days_____
(State) (County)

Comments:

Date_____ Name_____

Address_____

—Carlton M. Herman, Editor, California Fish and Game, July, 1946

IN MEMORIAM

BRICE L. HAMMACK

Fish and Game Warden Brice L. Hammack died at his home in Yreka on May 6, 1946 after a heart attack. Warden Hammack was born in Lake County and spent his early years in farming. He worked for the National Forest Service for several years and joined the division as a game warden in August, 1926. Since 1927 he served in Siskiyou County until his death at the age of 58. Hs was a highly respected citizen, loyal to his organization and intensely interested in all fish and game matters.

He is survived by a wife and two sons to whom we express our deepest sympathies.—*E. L. Macaulay, Chief, Bureau of Patrol, California Division of Fish and Game, July 8, 1946.*

REPORTS

FISH CASES

April, May, June, 1946

Offense	Number arrests	Fines	Jail sentences (days)
Abalones: taking abalone from shell below high water, undersize, failure to show, overlimit, no license, using license of another	298	$10,204 50	
Angling: refuse to show fish on demand, failure show license, closed stream, using set lines, no license, spearing, gaff 300 feet of stream, sunfish closed season, fishing near dam, other than angling, using non-native fish for bait, using net over 6 inches in length to take minnows	277	4,957 50	
Barracuda: undersize	1	30 00	
Bass: no license, night fishing, using more than one line, selling and buying striped bass	110	2,795 00	
Catfish: closed season, undersize, overlimit, no license, selling undersize	11	357 00	
Clams: undersize, overlimit, closed season, out of shell	36	1,126 50	
Commercial: netting salmon on Sunday, illegal diving, using drag net closed area, failure keep record, no shell fish dealers license, operating lampara net closed area, no license, failure show permit number on boat sides, trawl net closed area	69	4,015 00	
Crabs: undersize, overlimit	8	370 00	
Frogs: overlimit, undersize, with rifle, closed season	5	65 00	
Lobster: failure show license, overlimit, undersize, closed season, trape closed district, selling oversize	8	395 00	
Pollution	8	600 00	
Salmon: spawning bed, undersize, no license, closed season	20	840 00	
Sturgeon	1	25 00	
Trout: closed season, using more one line, closed stream, chumming, overlimit, selling, untagged domestic trout	163	5,142 50	20
Totals	1,015	$30,923 00	20

GAME CASES

April, May, June, 1946

Offense	Number arrests	Fines	Jail sentences (days)
Antelope: no permit	1	$50 00	
Deer: closed season, spike buck, at night, spotlighting	16	1,357 00	4
Deer meat: closed season, illegal possession, unmarked	18	680 00	
Doves: closed season, overlimit, failure show license	6	145 00	
Ducks: closed season, unplugged gun	15	520 00	
Florida Gallinules	1	50 00	
Geese: closed season	4	275 00	
Grey squirrel	1	50 00	
Hunting: firearms refuge, at night, no license, shooting from highway	17	380 00	
Nongame birds: no permit	1	5 00	
Pheasant: shooting from vehicle, hen, closed season, no license, refuge	34	1,955 00	
Quail: closed season	7	480 00	
Rabbit: spotlighting, closed season, refuge, at night, no license	49	1,055 00	
Trapping: no license, disturbing traps	4	50 00	
Trespassing	2	25 00	
Totals	176	$7,047 00	4

SEIZURES OF FISH AND GAME

April, May, June, 1946

Fish:	
Abalone	2,014
Bass, pounds	35
Bass	76
Catfish, pounds	5
Catfish	15
Clams	582
Crappie	23
Frogs	54
Kelp and rock bass	22
Lobster	85
Lobster traps	12
Perch	10
Salmon	3
Sturgeon	1
Sunfish, pounds	9
Sunfish	389
Trout, pounds	90
Trout	581
Game:	
Deer	3
Deer meat, pounds	263
Doves	19
Ducks	13
Florida Gallinules	1
Geese	10
Pheasants	22
Quail	13
Rabbit	8

FINANCIAL STATEMENT—DIVISION OF FISH AND GAME

Expenditures for the Period July 1, 1945, to June 30, 1946, of the Ninety-seventh Fiscal Year

Function	Salaries and wages	Operating expenses	Equipment	Total
Administration:				
Education and public information	$4,811 29	$7,695 03	$87 21	$12,593 53
Executive	9,205 00	6,417 99		15,622 99
Exhibits		112 31		112 31
Fish and game magazine		2,564 01		2,564 01
Library	2,310 21	530 83	135 22	2,976 26
Office	15,448 61	92,521 90	199 80	108,170 31
Total Administration	$31,775 11	$109,842 07	$422 23	$142,039 41
Patrol and Law Enforcement				
Airplane		$1,747 59	$9,722 13	$11,469 72
Cannery inspection	$18,451 16	217 71		18,668 87
Executive	23,374 61	4,061 00	7,175 00	34,610 61
Land patrol	302,648 12	136,323 42	—2,682 89	436,288 65
Marine patrol	60,991 98	48,021 59	23,572 75	132,586 32
Office	12,031 48	2,290 56		14,322 04
Pollution patrol		726 77		726 77
Total Patrol and Law Enforcement	$417,497 35	$193,388 64	$37,786 99	$646,672 98
Marine Fisheries:				
C.V.W.P. and salmon study	$16,255 71	$11,911 48	$812 65	$28,979 84
Executive	8,969 58	2,427 62		11,397 20
Fish cannery auditing		5,390 78		5,390 78
Laboratory	4,581 86	2,649 81		7,211 67
Library		28 74		28 74
Mackerel	2,682 57	108 58		2,791 15
Office	10,143 79	1,273 89	347 12	11,764 80
Sardines	9,590 01	1,757 38		11,347 30
Shark investigation	4,190 97	625 05	18 45	4,834 47
Shellfish and miscellaneous	2,970 00	672 02		3,642 02
Statistics	24,151 33	7,862 79	37 60	32,051 72
Total Marine Fisheries	$83,515 82	$34,708 14	$1,215 82	$119,439 78
Fish Conservation:				
Biological survey	$20,145 70	$4,729 06	$664 14	$25,538 90
Executive	11,530 00	1,892 89	12 81	13,435 70
Field inspection		3 53		3 53
Field supervision	6,340 00	1,628 58	8,644 76	16,613 34
Fish food unallocated		41,252 52		41,252 52
Fish planting		548 64		548 64
Fish rescue	11,199 75	3,471 27		14,671 02
Fish screens		739 04		739 04
Office	8,198 40	366 79	178 91	8,744 10
Operating expense unallocated		638 44		638 44
Pollution inspection	1,404 00	96 20		1,500 20
Statistical		255 94		255 94
Stream improvement	830 00	438 64		1,268 64
Structural maintenance		103 20	1,545 71	1,649 00
Unallocated		4,154 96		4,154 96
Alpine Hatchery		20 84		20 84
Arrowhead Lake Hatchery		11 25		11 25
Basin Creek Hatchery	5,207 62	1,664 08		6,811 70
Benbow Dam	1,491 00	79 88		1,570 88
Black Rock Springs		289 31	19 20	308 51
Bogus Creek Egg Collecting Station		85 00		85 00
Brookdale Hatchery	6,707 03	2,084 09	202 08	8,993 80
Burney Creek Hatchery	7,570 85	1,694 29	161 25	9,426 39
Central Valley Hatchery	7,282 90	2,870 50	200 43	10,353 83
Copco Egg Collecting Station		85 00		85 00
Coy Flat Hatchery	495 02	146 06	9 49	650 57
Crystal Lake Hatchery		2 00		2 00
Experimental Hatchery	450 00			450 00
Fall Creek Hatchery	5,689 24	1,019 58	26 09	6,734 91
Feather River Hatchery	3,060 32	732 48	183 49	3,976 29
Fillmore Hatchery	20,033 23	19,819 19	1,048 74	40,901 16
Fishing Creek Hatchery		31 25		31 25
Hot Creek Hatchery	19,190 88	26,813 55	76 76	
			3 00	46,084 19
Huntington Lake Hatchery	175 00	489 48		664 48
Kaweah Hatchery	5,716 32	1,447 27	880 35	8,043 94
Kern Hatchery	3,891 33	1,487 47	157 43	5,536 23
Kings River Hatchery	5,997 22	2,179 11	954 63	9,130 96
Klamathon Hatchery		1,333 91		1,333 91
Lake Almanor Hatchery	8,064 50	2,545 27	223 43	10,833 20
Madera Hatchery		59 28		59 28

FINANCIAL STATEMENT—DIVISION OF FISH AND GAME

Expenditures for the Period July 1, 1945, to June 30, 1946, of the Ninety-seventh Fiscal Year—Continued

Function	Salaries and wages	Operating expenses	Equipment	Total
Fish Conservation—Continued				
Mt. Shasta Hatchery	45,323 87	14,861 44	327 96	60,513 27
Mt. Tallac Hatchery	2,961 93	2,385 53	240 76	5,588 22
Mt. Whitney Hatchery	21,572 13	20,594 59	940 00	43,106 72
Mt. Whittier Hatchery	360 00			360 00
Potter Valley Hatchery	1,050 00			1,050 00
Prairie Creek Hatchery	5,966 98	1,339 44	56 36	7,362 78
Rush Creek Hatchery	900 00	94 80		994 80
San Gabriel Hatchery	300 00	349 97	40 51	690 48
San Lorenzo Hatchery		66 07		66 07
Sequoia Hatchery	3,562 03	1,860 22	55 51	5,477 76
Shasta River Hatchery	303 50	87 00		390 50
Snow Mountain Hatchery		459 34	9 74	469 08
Tahoe Hatchery	10,467 64	3,057 28	299 56	13,824 48
Tuolumne	580 00			580 00
Upper Truckee Egg Collecting Station		10 00		10 00
Whittier Hatchery	3,260 00	971 41	44 00	4,275 41
Yosemite Hatchery	6,170 69	1,056 47	33 75	7,260 91
Yuba River Hatchery	3,018 06	191 70	15 63	3,225 39
Unallocated		12 18		12 18
Total Fish Conservation	$266,467 14	$174,640 91	$17,256 48	$458,364 53
Engineering:				
Engineering	$2,665 15	$778 27		$3,443 42
Executive	2,231 12	254 06		2,485 18
Inspection of fish screens	360 00	756 06		1,116 06
Office	380 00	7 10		387 10
Total Engineering	$5,636 27	$1,795 49		$7,431 76
Game Conservation:				
Elk refuge	$2,415 00	$716 36	$13 15	$3,144 51
Executive	12,060 00	3,030 35		15,090 35
Game management	22,657 22	15,830 17	159 13	38,646 52
Grey Lodge Refuge	5,212 20	812 69	589 91	6,614 80
Honey Lake Refuge	6,421 40	4,200 60	2,786 36	13,408 36
Imperial Refuge	2,845 33	4,854 58		7,699 91
Imperial Valley Public Shooting Lodge		797 70		797 70
Los Banos Refuge	4,490 00	1,987 13	571 37	7,048 50
Office	5,881 87	425 82	28 15	6,335 84
Predatory animal—lion hunting	6,810 00	11,197 80		18,007 80
Predatory animal trapping	48,410 66	25,767 52	2,320 92	76,499 10
Predatory birds		203 70		203 70
Research	16,016 77	5,851 36	460 18	22,328 31
Riverside		10 65		10 65
Suisun Refuge	5,385 00	1,122 74	1,530 37	8,038 11
Statistics		852 18		852 18
Unallocated		736 91	1,975 18	2,712 09
Winter feeding and salt		441 65		441 65
Total Game Conservation	$138,605 45	$78,839 91	$10,434 72	$227,880 08
Game Farms:				
Castaic Farm	$2,152 49	$99 97		$2,252 46
Chino Game Farm	104 39	160 73		265 12
Executive	4,451 75	151 44		4,603 19
Fresno Game Farm	4,788 90	1,762 90		6,551 80
Game Bird District—Los Serranos	1,725 17	60 78		1,785 95
Game Bird District—Yountville	1,910 39	226 43		2,136 82
Game management	690 00	8 15		698 15
Los Serranos Game Farm	12,789 06	9,346 08		22,135 14
Office	2,010 00	371 14		2,381 14
Redding Game Farm	3,617 92	971 75		4,589 67
Sacramento Game Farm	4,192 58	702 54		4,895 12
Valley Center Game Farm	420 00	46 40		466 40
Willows Game Farm	3,352 92	672 05		4,024 97
Yountville Boarding House	3,295 15	3,525 81		6,820 96
Yountville Game Farm	18,394 54	15,431 56		33,826 10
Total Game Farms	$63,895 26	$33,537 73		$97,432 99
Licenses:				
Executive	$6,885 00	$1,176 42		$8,061 42
License distribution	19,920 07	140,992 66	$757 51	161,670 24
Office	1,835 00	562 35	2 57	2,399 92
Total Licenses	$28,640 07	$142,731 43	$760 08	$172,131 58

FINANCIAL STATEMENT—DIVISION OF FISH AND GAME

Revenue for the Period July 1, 1945, to June 30, 1946, of the Ninety-seventh Fiscal Year

	Detail	Total
Revenue for Fish and Game Preservation Fund:		
License revenue:		
1946 series—		
Angling:		
Citizen	$737,079 00	
Nonresident	8,928 00	
Alien	5,950 00	
Duplicate	237 00	
Angling control		$752,194 00
Hunting:		
Citizen	$40 00	
Junior	2 00	
Declarant alien	10 00	
Hunting control		52 00
Fish packer and wholesale shellfish dealer:		
Citizen	$75 00	
Alien	20 00	
Fish packer and wholesale shellfish dealer		95 00
Deer tags	$7 00	
Fish tags	2,205 00	
Game tags	98 85	
Market fishermen	73,970 00	
Fish importers	45 00	
Fish party boat permits	384 00	
Fish breeder	350 00	
Game breeder	2,675 00	
Kelp license	40 00	
Game management area licenses	100 00	
Game management area tags	84	
		79,875 69
Total 1946 series		$832,216 69
1945 series—		
Angling:		
Citizen	$773,084 00	
Nonresident	12,571 00	
Alien	5,600 00	
Duplicate	1,582 50	
Angling control		$792,837 50
Hunting:		
Archery—citizen	$132 00	
Citizen	677,570 00	
Junior	36,994 00	
Nonresident	38,780 00	
Declarant alien	2,775 00	
Alien	3,300 00	
Duplicate	1,540 00	
Hunting control		761,091 00
Community Hunting Club:		
Citizen	$800 00	
Community hunting club control		800 00
Community hunting club operator:		
Citizen	$240 00	
Community hunting club operator control		240 00
Trapping:		
Citizen	$1,753 00	
Alien	30 00	
Trapping control		1,783 00
Fish packer and shellfish dealer:		
Citizen	$1440 00	
Alien	20 00	
Fish packer and shellfish dealer control		1,460 00

FINANCIAL STATEMENT—DIVISION OF FISH AND GAME

Revenue for the Period July 1, 1945, to June 30, 1946, of the Ninety-seventh Fiscal Year—Continued

Archery	$31 00	
Deer tags control	214,500 00	
Fish tags	2,306 00	
Game tags	92 50	
Market fishermen	54,060 00	
Fish importers	5 00	
Fish party boat permits	162 00	
Fish breeder	50 00	
Game breeder	140 00	
Kelp license	110 00	
Game management area licenses	40 00	
Game management area tags	24	
Antelope permits	2,500 00	
Deer meat wardens	438 00	
Deer meat lockers	7,397 00	
		281,834 85
Total 1945 series		$1,540,146 35
1944 series—		
Angling:		
Alien	None	
Citizen	$1,434 00	
Duplicate	4 00	
Nonresident	6 00	
Angling control		$1,452 00
Hunting:		
Citizen	$11,353 00	
Junior	770 00	
Nonresident	90 00	
Declarant alien	20 00	
Duplicate	62 50	
Hunting control		12,295 50
Deer tags	$70 00	
Fish tags	28	
Pheasant tags	112 00	
Deer meat lockers	15 00	
		197 28
Total 1944 series		$13,944 78
Subrevenue		$2,686,307 82
Other revenue:		
Court fines	$80,042 95	
Lease of kelp beds	1,384 50	
Fish packers tax	266,148 51	
Kelp tax revenue	2,560 58	
Salmon packers tax	61,541 65	
Miscellaneous revenue	10,142 10	
Interest on surplus money investment fund	1,384 86	
Sale of boat	68,048 86	
Total other revenue		$471,197 01
Grand total, Fish and Game Preservation Fund		$3,157,504 83

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